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(54) TITLE: Liquid Crystal Image Display Device

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Specification

1. Name of Invention

Liquid Crystal Image Display Device

2. Claim of Patent

(1) In a liquid crystal image display device having liquid crystals retained between a pair of substrates and a matrix-like array of active switching elements on the above-mentioned liquid crystals on the substrate as a method to control the electro-optic effect of the liquid crystals, characteristically, a matrix-like array of microlenses is placed on the other substrate.

(2) In a liquid crystal image display device consisting of liquid crystals between a pair of substrates to control the electro-optic effect, with electrodes in a lattice array, characteristically, a matrix-like array of microlenses is placed on the substrate.

(3) In Claims (1) and (2), characteristically, the substrate having microlenses is a color separation filter.

3. Detailed Explanation of Invention

[Industrial Field of Application]

This invention pertains to liquid crystal imaging devices.

[Summary of Invention]

In a liquid crystal image display device having liquid crystals retained between a pair of substrates and matrix-like array of active switching elements

on the above-mentioned liquid crystals on the substrate as a method to control the electro-optic effect of the liquid crystals, a matrix-like array of microlenses are placed on the other substrates; or, for a simple matrix liquid crystal imaging device having orthogonally arranged electrodes, characteristically, microlenses are arranged in a matrix-like manner on the opposite substrate. Additionally, it is characterized that the above-mentioned microlenses are placed on a color separating filter. A liquid crystal display device having a high contrast ratio without sacrificing the brightness can be obtained by the above-mentioned array of microlenses.

[Conventional Technology] [Prior Art]

In a conventional liquid crystal display device, the leakage of light from other than the imaging element during the total black-display mode decreases the contrast ratio, so to improve the contrast the nonimaging element part is covered with a thin film of a metal. Or, another method is the placement of a pair of polarizing plates at a given angle to block off the stray light from the nonimaging part during a black-display mode period when no potential is applied.

[Problems To Be Solved By Invention and Objective of Invention]

The contrast ratio may be improved by covering the nonimaging part area with a thin metal film, but during the white-display mode period, the light absorption and scattering occur on the metal thin film part. When no potential is applied, a black-display period, colorization may occur due to double refraction and the colorization may be affected further by temperature effect. The invention will solve such problems; the objective is to provide a liquid crystal

imaging display device with a high contrast ratio without sacrificing the brightness.

[Means for Solving Problems]

In a liquid crystal image display device having liquid crystals retained between a pair of substrates and matrix-like array of active switching elements on the above-mentioned liquid crystals on the substrate as a method to control the electro-optic effect of the liquid crystals, a matrix-like array of microlenses is placed on the other substrate; or, for a simple matrix liquid crystal imaging device having orthogonally arranged electrodes, characteristically, microlenses are arranged in a matrix-like manner on the opposite substrate. Additionally, it is characterized that the above-mentioned microlenses are placed on the color separating filter.

[Effects]

The effect of the invention will be discussed on the basis of Figure 1. In the embodiment of the invention, incident light beams, 8, are collected on imaging electrodes, 7, by microlenses, 3, and the entire incident light beams can be controlled on the imaging electrodes because the light beams strike neither on the active switching elements nor on the wiring and electrode zones. In other words, all of the incident light beams will pass through transparent electrode, 5, during a total white-display mode, and the light beams can be controlled by imaging electrode, 7, during a total black-display mode; hence, there will not be any light leakage. In this manner, an image with a high contrast ratio can be constructed without sacrificing the brightness.

[Example 1]

This example will be discussed on the basis of Figure 1. Figure 1 is a cross-sectional view of a TFT color liquid crystal display element, and it has a matrix-like polysilicon thin film transistor (TFT) as a switching element on , transparent quartz substrate, 5. Color filter layer, 2, was formed on the opposite substrate, 1, by a photographic process, printing, and pigment vapor deposition. A methacrylate base negative resist was spin coated on the color filter, and this was exposed and developed by conventional photographic process; then the negative resist was over etched to form microlenses, 3, in a matrix-like array. The above-mentioned resist is not limited to one with a methacrylate base. Any transparent resin can be used, for example, polyvinyl alcohol polyvinyl cinnamate, and natural protein such as gelatin. Subsequently, transparent common electrode, 4, was formed on the microlenses. A spacer and gapping agent were applied between a pair of substrates to form a liquid crystal cell and liquid crystals were filled in.

The characteristics of the product from this example are illustrated in Figure 5 and 6. Figure 5 is a graph showing the voltage dependence of the transmittance; line 1 is the result when the microlenses of the example were used, and line 2 is the result when conventional black stripes were used.

The graph demonstrates the improved brightness and contrast ratio by using the microlenses of the invention when compared with the conventional black stripes. Figure 6 is a chromaticity diagram, and line 1 is the result from microlenses formed by the method of this example and line 2 is the result of using conventional black stripes. The figure shows that when the black stripes were used, then the chromaticity coordinate broadens.

[Example 2]

This example will be discussed on the basis of Figure 3. Figure 3 is a cross-sectional view of a simple matrix color liquid crystal display device and common electrode, 4, was formed on a transparent quartz substrate. A color filter was formed on one side of the common electrode by a photographic process, printing, pigment vapor deposition, etc. A transparent methacrylate base negative resist was spin coated onto the color filter, and then exposed and developed by using a photographic process; the negative resist was overetched to form microlenses, 3. A pair of substrates was formed into a liquid crystal cell by placing the substrates so that the black stripes were orthogonal to each other, by using spacers and a gapping agent, and then liquid crystals were filled into the cell and sealed.

The liquid crystal imaging device using the microlenses of the invention provides improved brightness and contrast ratio; it also provides a widened color coordinate.

[Example 3]

This example will be discussed on the basis of Figure 4. Figure 4 is a cross-sectional view of an MIM color liquid crystal display device, and a metal-insulator-metal (MIM) diode was placed on one of the substrates as the switching element. On the opposite substrate, color filter, 2, was formed by a photographic process, printing, and pigment vapor deposition. Additionally, on the color filter, a novolak type far-infrared resist was spin coated, patterned, and annealed above the glass transition point. Subsequently, as a second layer, the above-mentioned far infrared resist was coated on in a pattern and annealed above the glass transition point to form microlens, 3. Transparent common electrode, 4, was formed on the microlenses. By using spacers and a gapping

agent, a cell was formed with the pair of substrates and liquid crystals were filled into the cell and sealed.

The liquid crystal imaging device of the invention using the microlenses of the invention was obtained by the above method, and the device provides a brighter, higher contrast ratio and a broadened color coordinate than a conventional black stripe using a liquid crystal image display device.

[Effect of Invention]

As described above, according to the invention, by forming microlenses, the light transmittance has been improved, the brightness of the displayed image has been increased, and the contrast has been improved. Also, when a color filter was formed on the microlenses, a full color display image that is finer than a conventional image can be obtained.

4. Explanation of Figures

Figure 1 is a cross-sectional view of the TFT color liquid crystal display device.

1...Transparent substrate 2...Color filter

3...Microlenses 4...Transparent electrode

5...Quartz substrate

6...Polysilicon thin film transistor

7...Imaging electrode 8...Incidence light.

Figure 2 is a cross-sectional view of a conventional TFT color liquid display device.

1...Transparent substrate 2...Color filter

3...Transparent electrode 4...Quartz substrate

5...Black stripe

6...Polysilicon thin film transistor

7...Imaging electrode

8...Incident light.

Figure 3 is a cross-sectional view of a simple matrix color liquid crystal display device.

1...Transparent substrate

2...Color filter

3...Microlenses

4...Transparent electrode

5...Incident light.

Figure 4 is a cross-sectional view of an MIM color liquid crystal display device.

1...Transparent substrate

2...Color filter

3...Microlenses

4...Transparent electrode

5...MIM

6...Imaging electrode

7...Incident light.

Figure 5 shows the voltage dependence of transmittance.

1...Display using microlenses

2...Display device using black stripe.

Figure 6 shows the chromaticity.

1...Display using microlenses.

2...Display device using black stripe.

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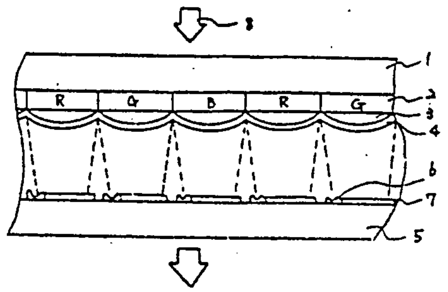

Fig. 1

Cross-sectional view of a TFT color liquid crystal display device.

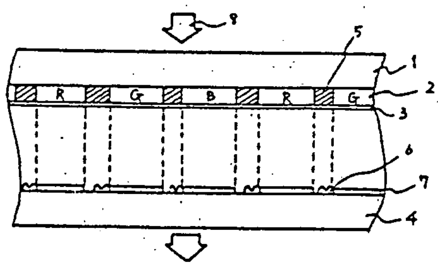

Fig. 2

Cross-sectional view of a conventional

TFT color liquid crystal display device

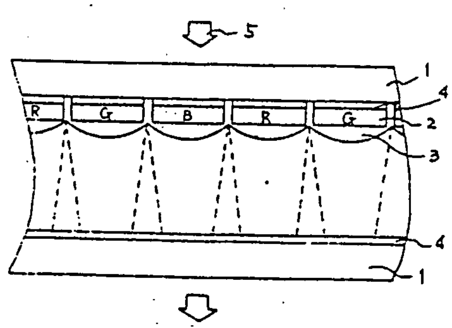

Fig. 3

Cross-sectional view of a simple matrix color

liquid crystal display device

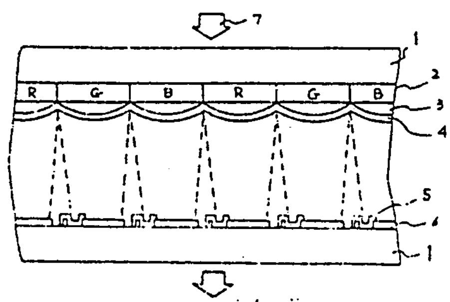

Fig. 4

Cross-sectional view of an MIM color display device

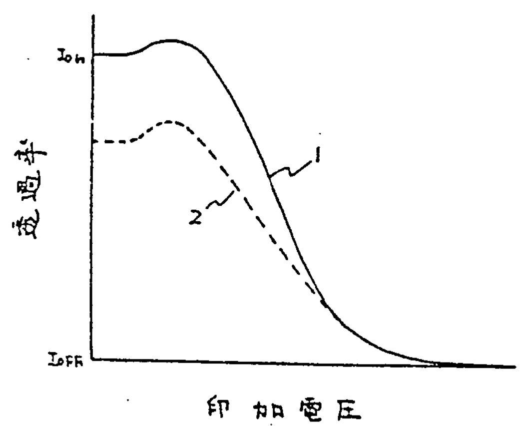

Fig. 5

Voltage dependence of transmittance

Left: Transmittance

Bottom: Applied voltage

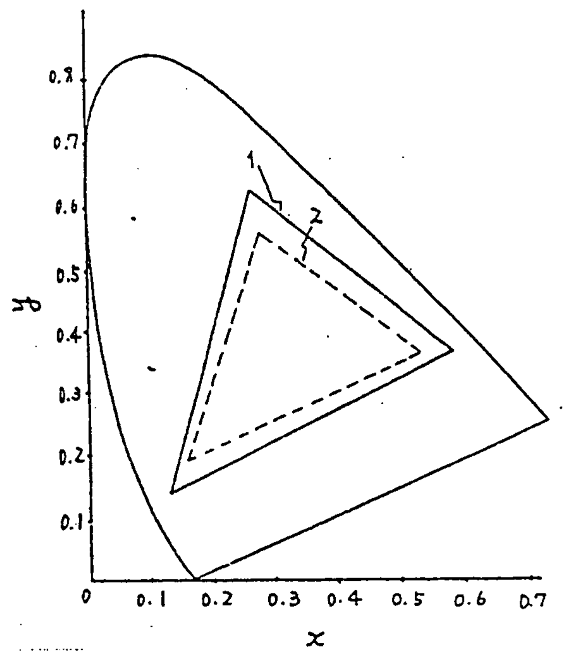

Fig. 6

Chromaticity